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THESIS

ESTABLISHING A PRODUCT BASELINE FOR GLOBAL POSITIONING SYSTEM SATELLITES THROUGH FUNCTIONAL AND PHYSICAL CONFIGURATION AUDITS

by

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September 2011

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Programs without a proper technical baseline will not be able to achieve cost, schedule, and/or performance objectives. The purpose of this thesis is to provide clear steps, methods, guidelines, and suggestions to mature the functional, allocated, and product baselines from the development baseline to the contract baseline for the acquisition of a Global Positioning System (GPS) space segment. Implementation of these recommendations will reduce cost and/or schedule for programs such as GPS across the Space and Missile Systems Center (SMC). The thesis better defines, recommends updates, and suggests tailoring for relevant sections in standards such as MIL-STD-1521B and MIL-STD-973. It narrows some of the policies established in the DoD 5000.2 and other commonly used space acquisition regulations while satisfying the GPS Wing System Engineering Plan (SEP) requirement for the completion of a Functional and Physical Configuration Audit (FCA/PCA). It also identifies some characteristics of conducting appropriate and efficient audits for space segment acquisition programs in the GPS Wing that can be adapted and applied to similar programs across SMC. Ultimately, this thesis attempts to set the foundation for SMC and/or Wing level plans, policies, and instructions used to establish the product baseline for space systems acquired at SMC.

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LIST OF ACRONYMS AND ABBREVIATIONS

ABCR	As Built Configuration Record
ABL	Allocated Baseline
ACD	Allocated Configuration Documentation
AD	As Designed
AFSPC	Air Force Space Command
AI&T	Assembly, Integration & Test
ATP	Acceptance Test Phase
CBL	Configuration Baseline
CCB	Configuration Control Board
CDD	Capability Development Document
CDR	Critical Design Review
Cert Sheet	Certification Sheet
CI	Configuration Item
CM	Configuration Management
COI	Critical Operational Issues
CONOP	Concept of Operation
CPD	Capability Production Document
CTB	Consent to Break (Configuration)
DAU	Defense Acquisition University
DCMA	Defense Contract Management Agency
DD	Department of Defense Form
DoD	Department of Defense
DoDAF	Department of Defense Air Forces
DodI	Department of Defense Instruction
ECP	Engineering Change Proposal
EOL	End of Life
ERB	Engineering Review Board
FAA	Federal Aviation Administration
FBL	Functional Baseline
FCA	Functional Configuration Audit
FCD	Functional Configuration Document
FOC	Final Operational Capability
GPS	Global Positioning System
GPS COI	Global Positioning System Community of Interest
GPSW	Global Positioning System Wing

IAW	In Accordance With
ICD	Interface Control Document
ICD	Initial Capabilities Document
IOC	Initial Operational Capability
IPT	Integrated Product Team
JCIDS	Joint Capabilities Integration Development System
JROC	Joint Requirements Oversight Council
KPP	Key Performance Parameter
LRIP	Low Rate Initial Production
MAR	Mission Assurance Review
MCB	Material Control Board
MIL-STD	Military Standard
NSS	National Security Space
ORD	Operational Requirements Document
PBL	Product Baseline
PC	Prime Contractor
PCA	Physical Configuration Audit
PCD	Product Configuration Document
PDR	Preliminary Design Review
PM	Program Manager
Proto Qual	Proto-Flight Qualification Program
PTR	Post Test Review
RFR	Run for Record
RM	Risk Management
SDR	System Design Review
SE	Systems Engineer(ing)
SEIT	Systems Engineering and Integration Team
SEP	Systems Engineering Plan
SMC	Space and Missiles System Center
SOW	Statement of Work
SRD	System Requirements Document
SRR	System Requirements Review
SV	Space Vehicle

T&E	Test and Evaluation
TBL	Technical Baseline
TCM	Test Compliance Matrix
TEMP	Test and Evaluation Master Plan
TOR	Technical Operation Report
TPM	Technical Performance Measure
TRD	Test Requirements Document
TRR	Test Readiness Review
USAF	United States Air Force
V&V	Verification and Validation

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I. INTRODUCTION

A. BACKGROUND

Systems can be defined as interoperating parts, pieces, components, subsystems, and/or segments with certain inputs, internal processes, and outputs intended to accomplish a given objective or set of objectives. To manage these independent entities as an operational system, it has become a common practice to identify requirements for each piece part based on the operating concept of the system and its overarching architectural framework. As these requirements are established at the highest level of the system and allocated down to the appropriate segments, subsystems, or components, it is a good practice to establish them as a requirement or technical baseline. When the respective aspects of the system are designed, a specification is typically authored to document how the item is to be built in a repeatable manner (i.e., production). With that in mind, a verification process should be used to make certain that the product has in fact been built to the specifications and/or functions as intended. To manage all the requirements, specifications, and processes, especially for a complex system of systems, it becomes necessary to manage these requirements, specifications, and resulting manufacturing and verification processes in terms of baselines and modifications in order to build and maintain a relevant operational system.

Specifically, Global Positioning System (GPS) requirements begin with user, operator, and/or customer requirements that are defined in terms of Key Performance Parameters (KPPs) in the GPS Operational Requirements Document (ORD) or Capabilities Development Document (CDD). These parameters, along with those from the system interface requirements in the Interface Control Documents (ICDs), are interpreted, validated, and delineated through the Joint Capabilities Integration Development System (JCIDS) or Air Force Space Command (AFSPC) requirements process to be transferred to the GPS Wing system requirements management process to provide the functional

performance requirements for the system and dictate how it will interact with interfacing systems. This process (illustrated in Figure 1) produces internal ICDs[1] for the interfaces of subsystems necessary to meet the higher-level requirements.

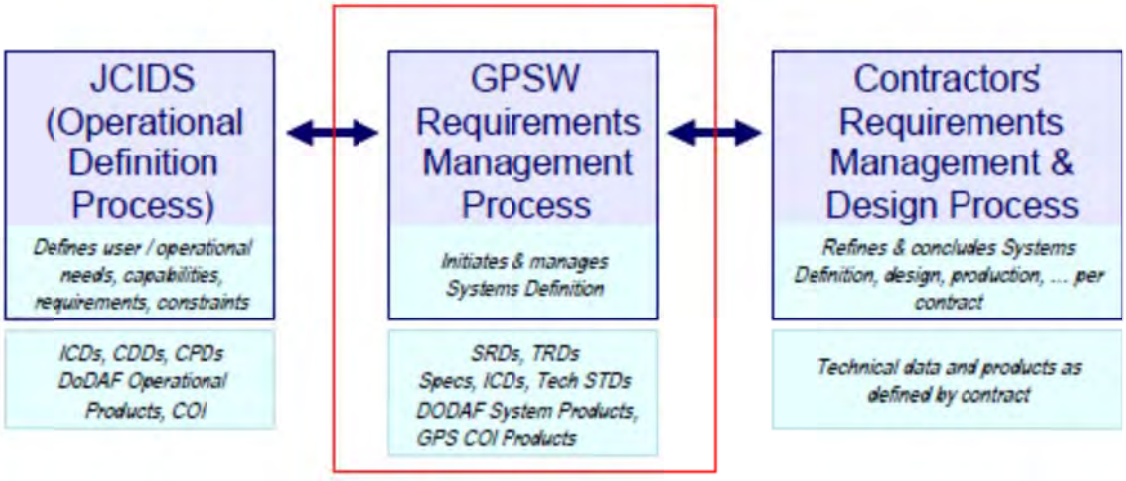

Figure 1. GPS Requirements Development Process (From: GPSW, 2008)

Once the user and operator requirements are identified, the GPS Wing uses three technical baselines to acquire, produce, and maintain GPS satellites, ground systems, and user equipment. According to the GPSW Systems Engineering Plan (SEP) of 22 September 2008 ((GPSW) 2008):

> The GPSW is a dynamic and multifaceted organization that is involved in sustaining, modernizing, developing, and managing the evolving GPS mission capabilities. The Wing's number-one priority is to sustain current capabilities for military and civil users worldwide. The foundation of the SEIT operation is management of the integrated system baseline (technical performance, schedule, and cost) and its associated interfaces. The program's chief priorities are to implement a low-risk schedule that sustains current system performance, meet phased performance requirements in an

[1] Interface Control Document (ICD), Capabilities Design Document (CDD), Capabilities Production Document (CPD), Department of Defense Air Force (DoDAF), Critical Operational Issues (COI), System Requirements Document (SRD), Technical Requirements Document (TRD), GPS Community of Interest (GPS COI), System Engineering and Integration Team (SEIT)

incremental fashion with time-certain delivery, provide system flexibility for future growth, and control total Government ownership costs.

Further, the system's operational baseline has been established starting with the initialization of the Block I system, and the sustainment and modernization is controlled through the management of this baseline. Subsequent improvements (Blocks II, IIR, IIR-M, IIF, and III) are the result of new requirements and identification of operational deficiencies by the system's users and operators.[2] Operator-identified deficiencies are corrected either by 50th Space Wing maintenance actions or are identified to HQ AFSPC [Headquarters Air Force Space Command] as needed capability improvements. A similar process exists at Warner Robins Air Logistics Center (WR-ALC) for the GPS UE [User Equipment]. These needs are documented as changes to the GPS CDDs [Capabilities Development Documents] and CONOPS [Concept of Operations] that are provided to SMC/GPSW [Space and Missile Systems Center/Global Positioning System Wing] to enable establishment of the next system Development Baseline. Because the 50th Space Wing implements changes to the operating configuration, care must be taken to ensure that the new system Development Baseline is consistent with the actual operating configuration. GPSW then allocates the system-level requirements to the segment Contract Baselines for the IPTs' (Integrated Product Team's) acquisition of the segment products. The three technical baselines can be defined as (1) the operational baseline, which represents the currently fielded, operational system capability; (2) the development baseline, which represents the functional, allocated, and product baselines for the planned upgrade to the system capability; and (3) the contract baselines, which are the segment-allocated portions of the development baseline that are managed by the IPTs and are binding on the development contracts.

[2] The first GPS satellites developed in the 1970s were referred to as Block I. After 9 satellites were successfully launched to demonstrate the concept and capabilities, Block II was developed and 9 more satellites were launched in 1989 and 1990 to provide the Initial Operational Capability (IOC). The ensuing improvements were implemented in an incremental block fashion up to the most recently launched Block IIF with enhanced signal strength, additional civil signals and modernized capabilities. Block III is in the initial acquisition design stages to be launched as early as 2014 (Wikipedia, June 2011).

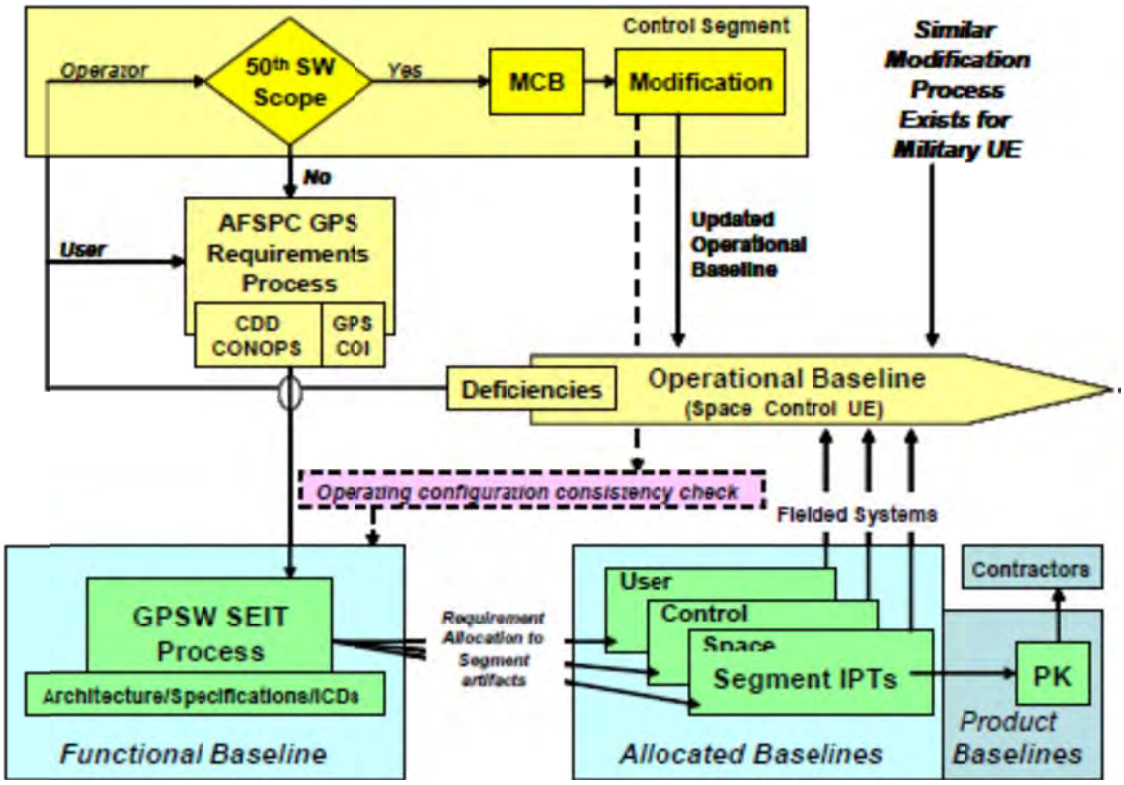

Figure 2. System Baseline Relationships (From: GPSW, 2008)

AFSPC is ultimately the customer that represents the Global Positioning System Community of Interest (GPS COI), which includes all users but consists of representatives from different user groups such as the Federal Aviation Administration (FAA), and various commercial companies. The operators for the GPS System, namely the 50th Space Wing, are shown in brighter yellow within as part of the Control Segment where a Material Control Board (MCB) is used to consider and make decisions on possible system modifications. For those items that are approved, an update is made to the Operational Baseline and passed to the Space Control User Equipment for any associated modifications as well as being passed through an operating configuration consistency check to become part of the next Functional Baseline that is to be acquired. The updates that cannot be made within the operator MCB Modification process are sent through the AFSPC requirements process to be refined and incorporated in the next possible functional baseline for acquisition by the GPSW. The GPSW uses the

Space System Acquisition process as specified by the System Engineering Integration and Test process identified in the GPSW SEP to result in the contracted procurement of the system by the Program Contracting division.

B. GPS BASELINE COMPONENTS

The Operational Baseline is the existing baseline that defines the previously acquired system that is currently in use, to include any modifications made by the operator through a MCB process. This baseline serves as the definition of the current system that provides for the legacy capabilities to be maintained and enhanced in an updated baseline through the acquisition process using the development baselines, namely the Functional, Allocated and Product Baselines.

The Functional Baseline (FBL) is the system level architecture, design, and interface specifications that are in turn allocated to the segmented subsystems for implementation in block upgrades through the Allocated Baseline(s) (ABLs) resulting in the respective contract or product baselines. The Product Baseline (PBL) is the contract baseline formally established for production through the technical review process that culminates in the Functional Configuration and Physical Configuration Audits (FCA/PCA).

The FBL consists of the specifications and documentation that describes the operational characteristics of the overall system and the architectural layout of the systems within the system, along with their associated design specification and interface control documentation. The Defense Acquisition Guidebook (Defense Acquisition University 2010) describes the FBL as follows:

> [The] Functional Baseline [is the] definition of the required system functionality describing functional and interface characteristics of the overall system, and the verification required to demonstrate the achievement of those specified functional characteristics. This baseline is derived from the Capability Development Document (CDD) and normally includes a detailed functional performance specification for the overall system and the tests necessary to verify and validate overall system performance. The functional baseline is

> normally established and put under configuration control at the System Functional Review. It is usually verified with… a Functional Configuration Audit (FCA).

The ABL is the documentation that describes the segments' operational, interoperational, and interface requirements as allocated from the higher-level system requirements. The system level requirements are allocated to the individual programs along with interface requirements, design constraints, and the verification required qualifying the design and demonstrating the achievement of the specified characteristics for the associated segment. For programs like GPS, the system is divided into space, ground, and user equipment systems (collectively referred to as subsystems) with generational acquisition program blocks and their associated subsystems and components. According to the DAU Guidebook, the ABL defines:

> The configuration items making up a system, and then how system function and performance requirements are allocated across lower level configuration items (hence the term allocated baseline). It includes all functional and interface characteristics that are allocated from the top level system or higher-level configuration items, derived requirements, interface requirements with other configuration items, design constraints, and the verification required to demonstrate the traceability and achievement of specified functional, performance, and interface characteristics. The performance of each configuration item in the allocated baseline is described in its preliminary design specification as are the tests necessary to verify and validate configuration item performance. The allocated baseline is usually established and put under configuration control at each configuration item's (hardware and software) Preliminary Design Review (PDR), culminating in a system allocated baseline established at the system-level PDR.

The final aspect of the Development Baseline, the Product Baseline or PBL, consists of all the documentation determined by the program Systems Engineering and Integration Team (SEIT) to describe sufficiently the physical and functional configuration of the end item as it is to be produced by the prime contractor. This may include documentation such as the design specifications or baseline, the As-Built Configuration Records (ABCRs), the requirements

verification process, any waivers or deviations on the vehicle functions or physical design, and the production process or build instructions. The design baseline is the documentation that defines the units, components and subsystems and how they are to be combined or integrated to meet the system or segment specifications. The ABCR is the documentation of the assembled hardware, the parts used, and the final configuration of how the space vehicle was actually built. The ABCR may differ slightly from vehicle to vehicle due to tolerances and acceptable variations in parts and material.

The PBL also serves to identify which functional and physical characteristics are to be verified during acceptance testing for workmanship confirmation. These requirements are typically identified through a requirements verification matrix that delineates the method to be used for the verification of each requirement. Each segment must break the ABL down into applicable specifications while verifying that the higher-level requirements are provided for in the specifications at that level. This verification is accomplished through the contractor requirements management process and should be accomplished as early as possible to prevent the redesign of lower level subsystems/components or rewriting lower level specifications. However, when programs, such as GPS, use proto-qualification as a means of verifying, validating, and qualifying the design and requirements for the space segment, the technical risk of insufficient system performance must be mitigated through support from the configuration control process. That is, approval and validation of the specifications and requirements at each level is accomplished through the Configuration Control Board (CCB) prior to the verification testing for the first flight article, as opposed

to building an expensive and time-consuming vehicle solely for testing[3]. Either way, this qualification process is the formal process by which a manufacturer's product is examined for compliance with the requirements of a source control drawing for the purpose of approving the manufacturer as a source of supply (Hagan 2009). This approval ensures that the design specifications meet the intent of the requirements and that the system is built and functions as designed. Accomplishing this early and in an iterative manner prevents late redesign work. Furthermore, a proto-qualification program allows the use of the initial flight article for physical testing to levels that ensure the system is robust without the potential impacts on longevity from the higher energy levels required for full qualification testing.

Finally, the production process and build instructions cover those items that are needed to describe how to accomplish each task during the assembly of the vehicle. Altogether, the PBL should specify what the customer is purchasing; how it should be built; and the testing needed to verify the requirements were met—all that is needed to recreate the same vehicle without prior knowledge of the specific system or the assembly process itself. These items should be defined and submitted for approval in the Critical Design Review (CDR), however, the PBL may see changes as the design is actually implemented. Such changes are typically for practical reasons of adapting to either specific applications or as-built configurations and can be made through an approved configuration management process without formal customer approval as long as there are no impacts to form, fit, or function. If so, the change is considered a

[3] For the purpose of this thesis, validation refers to only that of the requirement specifications, not the validation of the actual system. Validation then is the process of ensuring that the lower level specifications and as designed systems fully provide for what was intended by the higher level specification (i.e., requirement traceability between specifications). Verification is the act of showing that is actually the case for the system hardware and software through test, demonstration or analysis. The GPSW SEP states, "4.2.1.1.2.3 Development Baseline Requirements Validation. The GPS SE&I contractor is responsible for continued analysis of the DOORS database and the development baseline to ensure that all directed and statutory requirements are captured along with their full traceability. This requirements traceability and any changes to it are controlled by the GPSW Requirements Working Group and are captured within the change control process for validation by the CCB."

Class 1 change and requires an Engineering Change Proposal (ECP) to process the change through the government’s configuration management process. A key factor in reviewing these changes should be the determination whether they must be implemented in the current build, the next build, or only require documentation changes. Regardless, the documentation should be updated and revised accordingly to reflect the current configuration and document as a new baseline separate from previous versions or builds.

The Defense Acquisition Guidebook’s (Defense Acquisition University, 2010) defines the product baseline as follows:

> Documentation describing all of the necessary functional and physical characteristics of a configuration item; the selected functional and physical characteristics designated for production acceptance testing; and tests necessary for deployment/installation, operation, support, training, and disposal of the configuration item. The initial product baseline includes "build-to" specifications for hardware (product, process, material specifications, engineering drawings, and other related data) and software (software module design—"code-to" specifications). The Initial product baseline is usually established and put under configuration control at each configuration item's Critical Design Review (CDR), culminating in an initial system product baseline established at the system-level CDR. By DoD policy, the PM shall assume control over this initial product baseline after the system-level CDR and control all Class 1 changes. Until completion of the System Verification Review (SVR) and/or FCA, Class 1 changes shall be those changes that affect the government performance specification. Following the SVR/FCA, the government will further define contractually what constitutes a Class 1 change. The system product baseline is finalized and validated at the Physical Configuration Audit.

A well-defined development baseline (consisting of Functional, Allocated and Production Baselines, their equivalents, and/or the appropriate and approved waivers and deviations) documents what is planned and being accomplished, so it is critical for a design that provides a repeatable production and operational baseline for a space system that consistently meets the customer’s requirements. Without appropriate documentation, the configuration of the completed product may be unknown or inadequately replicated in production. To

accomplish a comprehensive review and to document changes through baselines, the GPSW SEP ((GPSW), 2008) states, “System/segment, prime item specifications, prime item fabrication, and critical items will be subject to configuration audits, namely the Functional Configuration Audit [FCA]/Physical Configuration Audit [PCA] to establish the product baseline. However, regarding the accomplishment of an FCA/PCA for individual programs the GPS Wing SEP ((GPSW), 2008) states, “Any contract-specific guidance or expectations are program unique; details on this subject are provided in the appropriate program annex of this SEP.” This means each program must research, assess, determine, establish, write, and accomplish its own FCA/PCA process. In establishing the FCA/PCA process, a program office is required to follow the technical review guidelines provided in *Department of Defense Instruction (DoDI) 5000.02, December 2, 2008* (Under Secretary of Defense (Acquisition, Technology and Logistics) 2008). This instruction is further defined in documentation such as the *Defense Acquisition University (DAU) Defense Acquisition Guidebook* (Defense Acquisition University 2010), the *Department of Defense Systems Engineering Plan Preparation Guide Version 2.01 April 2008* (Office of the Deputy Under Secretary of Defense for Acquisition and Technology 2008) and, previously, the *National Security Space Acquisition Policy Number 03-01 27 December 2004 (NSS 03-01)*. Although these documents provide policies and purposes, they do not establish lower level working guidelines and objectives for the execution of an FCA/PCA. Turning to Military Standards (MIL-STDs) 973 and 1521B on Configuration Management (CM) and Technical Reviews for Systems, Equipment and Software, one might hope to find a process for establishing a baseline, however, these standards do not provide any more than broad objectives and definitions. The general guidelines are insufficient for determining a process that will properly document the configuration. Instead, these documents do not provide specific tasks and instructions for accomplishing an FCA/PCA.

Generally, many standards are focused on programs of mass production with Low Rate Initial Production (LRIP) and subsequent Full Rate Production (FRP) phases. However, most space systems require relatively few space vehicles of the same design and architecture to populate a constellation and do not justify such an approach to production. Therefore, there are some common points in the MIL-STD Certification Sheets to tailor for space system acquisition programs. Tailoring the language in these certification sheets allows a Space System Acquisition Program to achieve the intent of the standard by making minor non-substantative revisions to the wording of the sheets for better application to the subject program. In the end, these sheets could be formalized as a MIL-STD Certification Sheet/appendix on their own for use in SMC space acquisition applications. See Appendix A (Global Positioning Systems Wing 2009) for an example of tailored Certification Sheets for a GPS Space Segment.

C. ASSUMPTIONS

1. The culminating event in a technical review process used for establishing the development baseline for the acquisition of a GPS space segment block upgrade is referred to as an FCA/PCA. This thesis focuses on the acquisition process that provides a product baseline as part of the development baseline for the incremental upgrade of the GPS system that is purchased in blocks, or a number of satellites that provides for the capabilities and interoperation with the existing system while providing the desired upgrades or additional life for the system.
2. Low quantity multi-vehicle programs. Although some of the existing guidance was written for higher volume production programs that often make use of LRIP and FRP phases, the process defined in this thesis provides the product baseline for satellite acquisition programs producing only enough satellites to populate an operational constellation or augment multiple aging satellites.
3. Differences in the generations of a space segment, between programs and the means of satellite acquisition at SMC are slight enough to allow standardization in guidance at some level below that of the current/relevant DoDIs, MIL-STDs and Aerospace Technical Operating Report (TOR). This allows for efficiency within a system program office, or equivalent, by providing a common process to be applied across multiple programs.

4. The contract(s) are set up in such a way to be able to consider the subcontracted products sufficiently audited to be included in a Prime Contractor's design baseline, requiring limited government oversight. To be discussed in Section II.

D. PURPOSE

This thesis focuses on the development baseline as it is documented, managed, and verified to, ultimately, establish the satellites' functional characteristics and physical configuration; delineate the system requirements; and establish the processes for development, testing, and requirements verification in the product baseline.

The generic objectives provided by higher-level policies are specified here in greater detail providing a process to accomplish the FCA/PCA as the final step in the technical review process for Space Segment Acquisition Programs in the GPSW. This innovation will provide a standard method for establishing the most up to date technical/operational baseline and may also provide a basis for similar standards in other programs at SMC. However, the primary intent was to tie multiple policies and instructions together to provide a common application as a foundation for program level planning in the program SEP as required by DoDI 5000.2:

> Technical reviews of program progress shall be event-driven and conducted when the system under development meets the review entrance criteria as documented in the SEP. They shall include participation by subject matter experts who are independent of the program (i.e., peer review), unless specifically waived by the SEP approval authority as documented in the SEP. (Under Secretary of Defense (Acquisition, Technology and Logistics))

> The PM shall use a configuration management approach to establish and control product attributes and the product baseline across the total system life cycle. This approach shall identify, document, audit, and control the functional and physical characteristics of the system design; track any changes; provide an audit trail of Technical reviews of program design decisions and design modifications; and be integrated with the SEP and technical planning.

The following shows the final review and establishes the technical baseline in terms of the relevant product, contract, and operational baselines.

E. RESEARCH QUESTIONS

This thesis answers several questions.

1. What are the necessary outputs of a technical review FCA/PCA?
2. What means should be used for the culmination of a technical review for a GPS Space Segment Acquisition Block?
3. What objectives and methods are appropriate for the government FCA/PCA process in order to establish the technical baseline for GPS and/or SMC space acquisition programs?
4. Which strategies are most beneficial for system engineering in the production of GPS Space Vehicles?
5. How can these objectives and methods be applied effectively for the acquisition of a GPS space segment?
6. What role does configuration management play in the maintenance of a technical baseline for production purposes?

F. BENEFITS OF STUDY

This thesis provides guidelines for establishing the Product Baseline of a program through the final phase of a government audit/review process. Starting with the certifications found in the MIL-STDs, which are a means of documenting the objectives and their accomplishment to provide for the intended outcome of the FCA/PCA, this study suggests tailoring of the MIL-STD provisions as appropriate for GPS Satellite acquisition. Several tools are then recommended to improve the execution of the FCA/PCA and the baselining process. In summary, the recommendations include the following.

1. Tailored certification sheets from MIL-STD-973 and/or MIL-STD-1521B to ensure that each area of the physical and functional configuration is properly addressed.
2. Entrance/Exit Criteria to provide criterion for the initiation and completion for the FCA/PCA.

3. Recommended structure for the FCA/PCA process, including the review types and the intersections with other program products and processes.
4. Recommendations for revisions to higher-level policies in accordance with (IAW) with the findings herein.

G. SCOPE AND METHODOLOGY

Beginning with the FCA/PCA definition found in the higher-level SMC policy (Aerospace) this thesis suggets a method by which a satellite design can be reviewed to establish a technical baseline for the production of a GPS space segment. The primary focus is on the culminating milestone of the technical review process known as the FCA/PCA, which is used to baseline the configuration documentation for programs in the GPSW at SMC. It points to acceptable processes, checklists, and certifications that can be used to approve the technical baseline resulting in the purchase of the final design by the government. The thesis incorporates aspects of existing guidelines and policies from DAU and the DoD (MIL-STD) to describe and recommend the products of an FCA/PCA. The thesis also provides suggestions on how to integrate these reference products with other tools frequently used in acquisition programs, such as risk management or the SEP. To do so, the following four steps were accomplished to understand common practices within the SMC/GPSW and provide the final products identified above.

1. Conducted literature review of applicable guidelines/policies in multiple fields to understand what is currently being used in the field.
2. Highlighted applicable AF and industry practices used in the design and technical baseline process for space system acquisitions.
3. Analyzed previous guidelines and standards, positing new standards for reference in the System Engineering and FCA/PCA process.
4. Developed recommendations for improving and standardizing the technical review and baselining process for the SMC and the GPSW.

II. THE FCA/PCA PROCESS

A. INTRODUCTION

The final milestone in the technical review process is, typically, a government audit, consisting primarily of the FCA/PCA, which is intended to support the acquisition life cycle by establishing an accurate product baseline that meets the user's needs to define how each vehicle is to be built. Typically, the FCA/PCA is the culmination of the qualification program and/or the acquisition phase following the CDR, delineated in the NSS 03-01 (Figure 3), and provides for the Build Approval/Production Decision. However, the FCA/PCA may be combined with a Proto-Flight Qualification (Proto-Qual) Program to be completed simultaneously with the first production/proto-qual vehicle, as is common for many space system acquisition programs. In any case, it completes the government audit of and agreement to the qualification of the system design while establishing the PBL for all follow-on acceptance vehicles, unless otherwise stated.

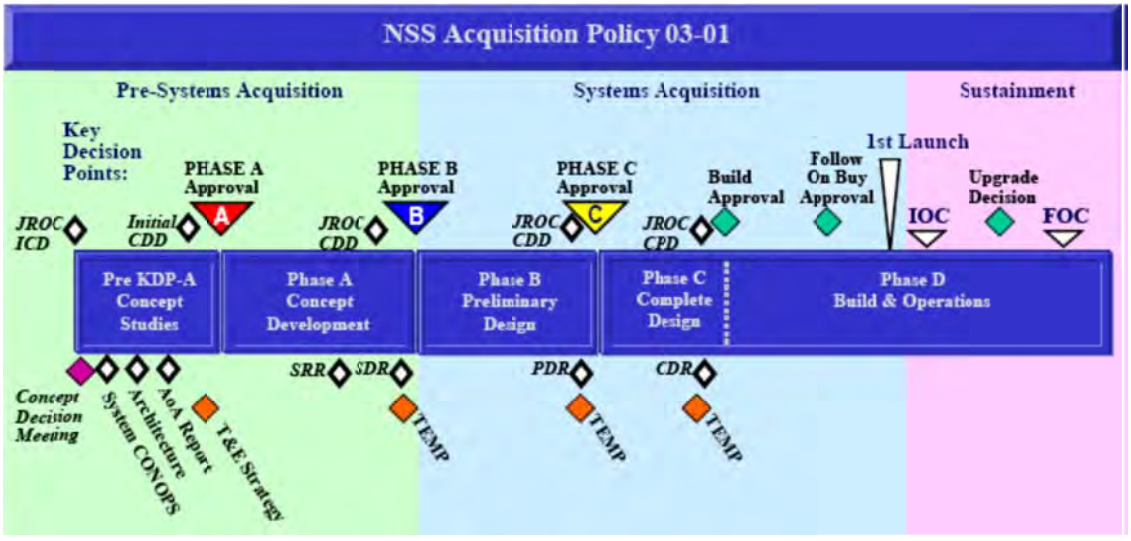

Figure 3. NSS 03-01 Acquisition Phases (From: Secretary of the Air Force [USA] 2004)

Although the acquisition process seems to be in a constant state of revision, the process generally follows what was established in the National Space Strategy Acquisition Policy 03-01, depicted in Figure 3. The process starts with the Pre-Systems Acquisition phase and the identification of a user or operator need that is formally approved and requested by the Joint Requirements Oversight Council (JROC) through an Initial Capabilities Document (ICD). At the time of approval, a Concept Decision Meeting is held to kick-off the Concept Studies phase for the development and proposal of possible Concepts of Operation (CONOPs) intended to highlight the functional characteristics to best achieve the objectives of the system. The CONOPs are then complimented by the definition and characterization of their respective Architectures, and the system infrastructure envisioned to provide the functionality required. An Analysis of Alternatives is then accomplished to consider and report the pros and cons of each concept. During this formative period, the JROC ICD is further specified in a CDD. Meanwhile, the Test and Evaluation (T&E) Strategy and the Integration Plan are drafted to ultimately provide for the test, and verification of the system requirements and system integration. The Concept Studies phase culminates in a decision on whether to proceed into Phase A for the development of a proposed concept.

In Phase A, a program develops the requirements and design for the formally conceptual system and reviews each in the System Requirements Review (SRR) and System Design Review (SDR). Additionally, the T&E Master Plan (TEMP) is developed based on the T&E strategy to document the process and requirements for verification and demonstration while the JROC CDD is updated with any changes necessary for the developing system. All of this development work is reviewed and considered for Phase B approval to proceed into the formal development of the system design.

Phase B consists of the preliminary design work to define the subsystems and interfaces to make up the system. It culminates in the aptly named Preliminary Design Review (PDR) and a decision to proceed into Phase C, along with an update to the JROC CDD and TEMP.

In Phase C, the design is brought to completion and approved in the Critical Design Review (CDR). Coincidently, the JROC CDD is transitioned from a planning document into a Capabilities Production Document (CPD) that describes what will actually be built, as opposed to what is being planned. At this point, the TEMP is finalized and the JROC CPD supports a build decision to proceed into Phase D Build and Operations.

The Build and Operations phase kicks-off the production of the first flight article, which can be used for full or “partial” proto-qualification testing, as defined in the glossary. A decision to buy follow on units is then made in conjunction with the final input from the FCA/PCA and the establishment of a production process or production line for to build the remaining articles to be purchased. If a proto-qualification program was used, the first article can be shipped and processed for the first launch followed by establishing the Initial Operational Capability (IOC) supported by a Post Deployment Review to determine whether a unit is in an acceptable operational condition and is able to be sustained and maintained. Once IOC is achieved, the sustainment phase begins for the operational units while production continues for any remaining units to be purchased and/or deployed. When all units required for Full Operational Capability (FOC) are deployed and considered operational, the FOC milestone can be declared complete, ending one acquisition cycle and starting the next for any subsequent upgrades.

B. PURPOSE OF THE TECHNICAL REVIEW AND FCA/PCA PROCESSES

The technical review process serves to mature a design and its supporting configuration documentation progressively, culminating in an FCA/PCA that provides the product baseline to be used as the contract baseline for production.

However, an FCA/PCA can take several forms that may be left to the discretion of the Program Manager (PM), the System Engineer (SE), and/or directed by higher-level policy. Depending on the scope and breadth of information and data to be reviewed for the program, the audit can be broken into incremental phases or completed as a single event, at the discrepancy of the PM and/or SE team(s). Whatever the case, the audit should incorporate information from the design and development, production and testing, systems engineering, integration, and program management aspects of the program. The primary intent is to review data from the Prime Contractor (PC). It is assumed all subcontractor and vendor products have been audited by the prime contractor to an acceptable level of scrutiny. Participation from the government, by invitation, is offered when possible and appropriate. Such participation by government is reasonable because it is a common practice that helps prevent government interference in subcontracts, holds the prime contractor accountable for their end product(s), limits the potential scope of the government audit. It is commonplace to include government participation by invitation in associated contract language. The units/components delivered to the PC will be considered baselined, at this associated level, as delivered and documented in the unit data package or equivalent prior to integration. Any changes after that, including the work to integrate the unit into the higher-level assembly, will be subject to government audit. Once the FCA/PCA is complete and the baseline established, the government will purchase the product as specified under contract and can take control of the final configuration and manage the baseline IAW the program contract and/or appropriate program directives/processes.

The FCA/PCA should serve to validate the contractor’s production process. The audit should typically consist of a thorough inspection of the ABCRs; the seller’s design baseline; and the production process/build instructions. The ABCR should be compared to the As-Designed (AD) Configuration to ensure that the product meets the intended configuration managed design. Any design changes, whether Engineering Change Proposals

(ECPs), and Engineering Orders (EOs) that have been implemented since the previously established baseline should be reviewed for accuracy, completeness, appropriateness, and acceptability. Then in order to compare this design baseline to the ABCR, the work/build instructions used for the assembly/production of the product, along with Quality Assurance inspection documentation, should be evaluated to determine whether they have been implemented appropriately, IAW applicable guidelines and directives, to ensure a consistent and high quality final product. In short, a review of the design baseline, ABCR, and work instructions should provide confidence from all parties that the contractor can safely, efficiently, and appropriately plan and direct a repeatable and adequate production process to build the final product(s).

The PCA portion of the audit for a space segment acquisition program should include a physical inspection of the final product that considers any potential cost impacts. This inspection will provide a verification that the assembly is built IAW the work instructions and procedures identified, which in-turn were reviewed in the ABCR to AD validation. Although, this review can be completed in several different ways, it is advantageous and efficient to leverage off the factory support provided by the Assembly, Integration, & Test (AI&T) team and Defense Contract Management Agency (DCMA) personnel who are involved in the day-to-day efforts. These support personnel can verify the build and installation real-time/in-process and document findings to provide for final AB verification without having to reaccess or reassess the hardware while consuming additional time and resources. The purpose of using the existing DCAM personnel is to prevent an added cost or resource need for the program while providing an independent review of the system/processes.

The other facet of the review process, the FCA, is intended to conclude the qualification/proto-qualification test phase and approve the “kick-off” of the Acceptance Test Phase (ATP) for Validation and Verification (V&V) of the allocated and functional aspects of the development baseline. The FCA includes requirement and test program V&V. At the completion of the FCA, all

requirements should be verified or waived to show that the design can either meet the intended operational performance for the system or operate with a known, analyzed, and documented acceptable deficiency, respectively. Finally, if there are any non-conformances for either the physical or the functional configurations they must be formally approved via waiver or deviation IAW the program contract parameters and CM policies and processes, or otherwise remedied. The waivers and deviations should be summarized in the final report/documentation of the technical review. In the end, the review should also provide an overall impact assessment of the waivers and deviations, collectively. This is a consideration in the following section on risk assessment.

C. ASSESSING RISKS TO PROCEED INTO PRODUCTION

One of the ultimate goals for establishing a high fidelity technical baseline is to provide the necessary input for a reliable production process. Production includes all activities directly associated with the manufacturing and assembly of the completed space segment system. These activities include tooling, supply chain management, part and component kitting, sparing, constructing or building, and labor force management. These activities typically accomplished by the AI&T team provide the end item for an acquisition program. To replicate the product for a multi-vehicle space system, a consistent application of a well-defined technical baseline is necessary. As stated in the assumptions, GPS Space Segment block acquisitions are for a limited number of space vehicles that implies fewer spares, if any, and typically is well accommodated by a proto-qualification program that can make use of the qualification vehicle as an operational asset instead of building a fully capable asset solely for the purpose of testing at pre-defined higher standards that prevent the item from being used for operational purposes. However, because a design or engineered system is never without flaw, the technical review process should serve to assess the risk of proceeding into the production of the remaining vehicles, in addition to the objectives stated above. To assess this risk, the technical review team (typically consisting of the program SEIT, AI&T team, independent reviewers, or their equivalents) will leverage on

several existing efforts, products, and resources. One of which includes the existing program Risk Management (RM) process and the associated risk status as well as any kind of Mission Assurance Review (MAR) or similar assessment that has been accomplished. Combining these efforts with the technical assessment completed during the technical review, the team should consider the cost, schedule, and technical risk to the program if the vehicle system is to proceed into production. Although the technical review will often be focused on a technical risk assessment related to the capability of the system, as designed, to meet operational performance or the Technical Performance Measures (TPMs) at the End of Life (EOL), this review should also consider the cost and schedule impacts that may be experienced. The technical review may even incorporate business and schedule risk assessments as required by the program SEP or PM.

As stated in the previous section, this technical assessment should include the cumulative impact of the deviations and waivers on the program. Once the margin available between the expected performance and the allocated requirement is determined, the SV program should complete an assessment of how the waived or deviated out-of-spec conditions, or non-conformances, cumulatively affect the expected EOL performance of the SV or system as a whole. With this analysis, a risk assessment can be completed to project the likelihood and consequences of failures associated with the out of spec conditions.

Inherently, some risk will always be present in the operation of an SV, however any significant risk should be considered to determine whether it can be worked around, is acceptable for flight as is, or if it should be mitigated through appropriate means. This decision is ultimately up to the Flight Readiness authority, but should be considered and mitigated when and where possible by the PM, Integrated Product Team (IPT), and PC throughout the development effort.

D. CHAPTER SUMMARY

The technical review and baselining process is the culmination of the design and development phase of the acquisition process. In the end, a product design and production process is not formally defined or qualified by the customer without the completion of an FCA/PCA, or a similar review. This review will produce a report, signed certifications, and the appropriate documentation to identify the product baseline as derived from the functional and allocated baseline. This product baseline is to be used for production and/or the acceptance testing on the program. If anything is lacking, it should be captured in liens, waivers, or deviations, as appropriate, and will be assessed for the risk to the program as it continues into production. The ultimate objective is to use the product baseline built on the allocated, functional, and existing operational baselines to provide an improved and upgraded system based on operational and user inputs, establishing a new operation baseline as shown in Figure 4.

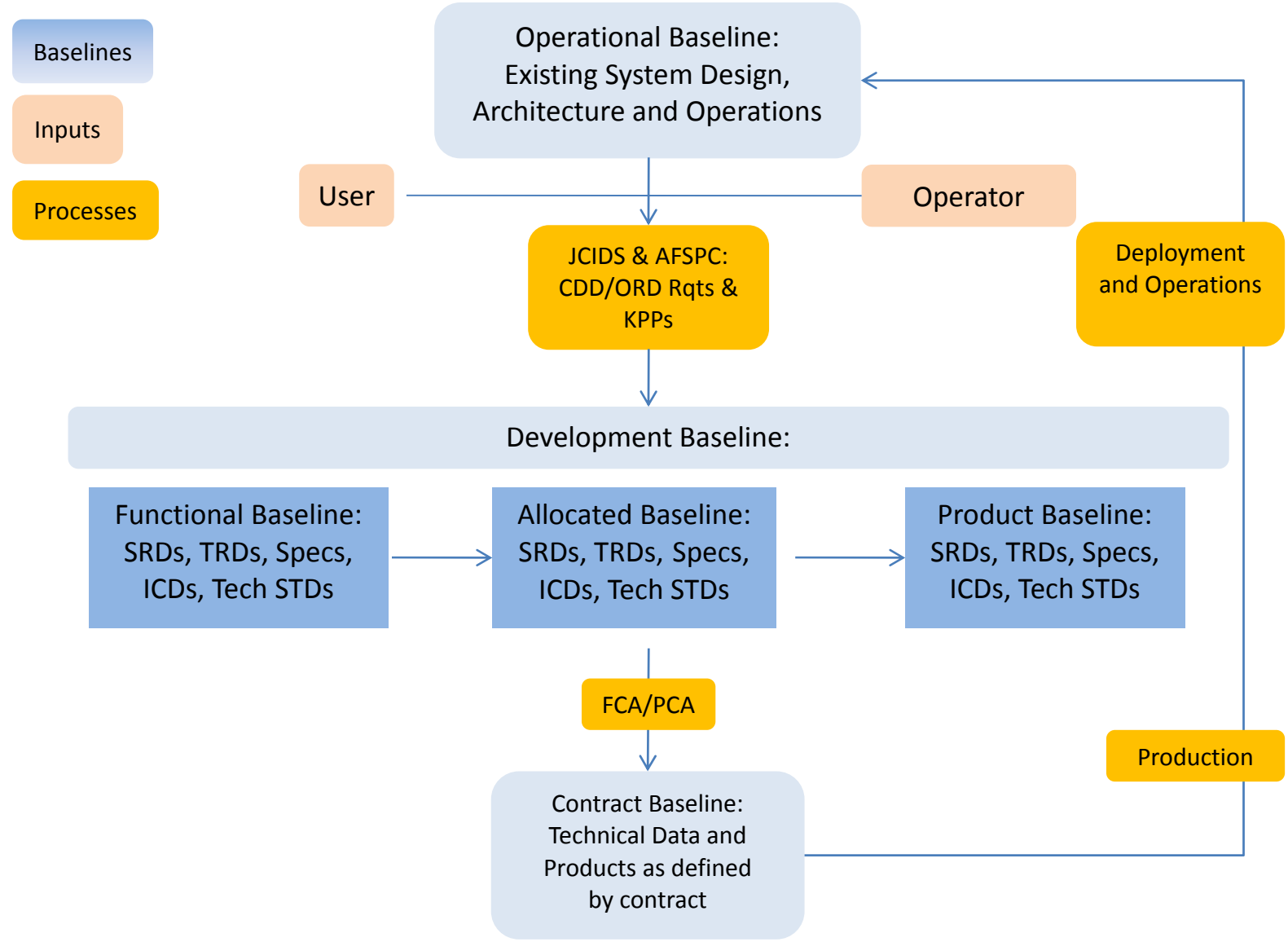

Figure 4. Baseline Inputs and Outputs

Beginning with the Operational Baseline consisting of the existing system design, architecture and operations, the JCIDS and the AFSPC work together, with inputs from the user and operations groups, to implement the requirements process in order to support the Chairman of the Joint Chiefs of Staff and the JROC in identifying, assessing, and prioritizing joint military capability needs as required by law. The capabilities are identified by analyzing what is required across all joint capability areas to accomplish the mission and codified in the CDD and ORD to capture the KPPs for the system. These documents feed the acquisition process to be broken down into SRDs, Technical Requirements Documents (TRDs), Specifications (Specs), Interface Control Documents (ICDs) and Technical Standards that are matured through each aspect of the Development Baseline and, finally, approved through the FCA/PCA for purchase through the Contract Baseline.

III. INTEGRATING COMMON PROGRAM PRODUCTS/TOOLS

A. INTRODUCTION

Many commonly used program tools can, or even should, be used in the FCA/PCA process. Some of these tools are useful for completing the audit(s), while others provide appropriate input or an interface to the program execution process. Some common program tools are described and suggested for use here.

B. SCHEDULING

The FCA/PCA for a program should be integrated into the program schedule and updated on a regular basis along with other program activities and milestones. However, a more detailed schedule of FCA/PCA activities may be appropriate and can be accomplished through the standard program scheduling team and tools. The FCA/PCA should qualify the AI&T process leading into production and can therefore validate the program schedule. If problems are identified, experienced, or noted, the baseline schedule and associated durations should be adjusted appropriately. Any specific occurrences should be documented as FCA/PCA Action Items.

C. CERTIFICATION SHEETS

Certification Sheets are intended to formally document the completion of certain critical activities in the FCA/PCA with an agreement and signature on what was accomplished related to the primary objectives of the event. An example of suggested content is provided in Appendix I of MIL-STD-1521B (DoD 1996) and MIL-STD-973 (DoD 1992); however, these requirements are contract or program dependent and the signature pages can be tailored as appropriate for the using program. MIL-STD-973 states, “This standard is applicable only to the extent specified in the tasking directive or contract Statement of Work (SOW). Contracts invoking this standard will specifically identify the appropriate

applicable paragraphs and Appendices, or portions thereof, in the tasking directive or—contract SOW. (See 6.2 for specific tailoring guidance.) The selection of necessary configuration management requirements from this standard to be applied to a specific program will be tailored to suit the life cycle phase, complexity, size, intended use (including joint and combined interoperability), mission criticality, and logistics support of the CIS." Once agreed to by the authoritative parties, and specified in the contract, the team can work to accomplish Certification Sheets for each applicable increment of the FCA/PCA. Appendix A of this thesis provides the MIL-STD Certification Sheets and suggested redlines that can be further refined based on the needs of the specific block, program, and contract.

D. TEST PROGRAM

The test program is a critical component of the FCA/PCA. The FCA/PCA is in fact not only meant to use the test program to verify requirements but is meant to actually validate and approve the test program while serving as a procedure review and, ultimately, a record of the requirement verification accomplished by the testing. Although verification can be achieved by demonstration or analysis, IAW the Requirements Verification Matrix, or equivalent, for a given requirements document, testing often provides for a majority of the verification, if possible, and is usually the most reliable method.

With this in mind, the FCA/PCA can leverage off the test program to accomplish a portion of the effort in conjunction with the Run for Record(s) (RFRs) of each test phase. The test program should include a review process for pre- and post-test activities related to test preparation and data review. This process is further delineated in the Aerospace Technical Operating Report, TOR-2007(8583)-6414 Volume 1 (Aerospace 2009); however, it is mentioned here as it feeds into the FCA/PCA. Test Readiness Reviews (TRRs) should be used to ensure that the testing is to be completed using the flight hardware, software, and test equipment configuration(s) needed in order to sell-off the RFR and

associated system requirements, as well as verify functionality and performance of the Space Vehicle (SV). Once the entrance criteria have been met, the TRR can be held. When all exit criteria for the TRR are completed, the review can be closed, approving the stated configuration and sequence of testing used to accomplish the test objectives (e.g., requirement verification). This means that a Test Compliance Matrix (TCM), or equivalent, has been compiled to identify which requirements are to be verified using specified test data. Then, after the test setup is complete, consent to test can be given and the test can commence. After the testing is complete and it is determined that the data is sufficient, meaning no retest is necessary for compliance purposes or troubleshooting and the current test configuration is no longer needed, a Consent to Break (CTB) configuration must be provided by the appropriate authorities. Next, a Post Test Review (PTR) should be accomplished to assess relevance and allocation of the data obtained and close out the test phase. Finally, a RFR meeting, or event, can be held to tie all the test data and FCA/PCA objectives together to provide for the related increment of the audit and functional performance verification.

Additionally, MIL-STD-1521B requires a review of the test procedures and results, including but not limited to all “test procedures and interface documents” as well as “All test data sheets… to assure that the test was witnessed by a representative of the Contracting Agency” IAW FCA Certification Sheets (Cert Sheets) 1 and 2, as tailored in Appendix A. Additionally, PCA CS 4, requires a review of “the acceptance test results… to ensure that testing is adequate, properly done, and certified” (USAF). To accomplish this review, a program should provide an SV representative to team with and/or be supported by a DCMA counterpart to witness and/or review the test data as close to real-time as possible. The initial review, to ascertain whether all necessary information is properly recorded based on the plan approved via the TRR, should be completed before a CTB configuration is provided. This verification is necessary in order to prevent a retest if a test objective was not appropriately provided for. The SV rep can then prepare a full test report to address the successes and shortcomings of

the test, to include any anomalies or failures requiring a waiver or change in script, process or configuration. This planning and review process should also identify the subset of tests to be run as part of the acceptance test phase for production vehicles after the qualification phase, to be agreed to and validated IAW the FCA/PCA Cert Sheets.

E. ACTION ITEMS AND MEETING MINUTES

In order to document the activities and accomplishments, minutes should be taken and recorded during the FCA/PCA event(s). Additionally, in order to ensure completeness, action items should be captured to identify and track any follow-on tasks necessary to close each event. These should be classified for level of severity to show criticality based on time required and/or technical impact. Category I is typically defined as those items that impact the technical baseline, impact one or more of the FCA/PCA objectives, are a constraint to "closing" the event, or should be "closed" within a designated timeframe. Category II is typically something that does not affect the purpose of the event or can be "closed" outside of the restricted timeframe specified for Category I Action Items. Finally, category III can be used to identify something that does not affect the event or program schedule, is to be completed by another party, and/or does not need to be completed near term.

F. CONFIGURATION MANAGEMENT

Using the FCA/PCA process, CM plays a critical role in establishing and maintaining the technical baseline for a program. Pg 78 of DoDI 5000.2 dated 08 December 08 states:

> The PM shall use a configuration management approach to establish and control product attributes and the technical baseline across the total system life cycle. This approach shall identify, document, audit, and control the functional and physical characteristics of the system design; track any changes; provide an audit trail of Technical reviews of program progress shall be event-driven and conducted when the system under development meets the review entrance criteria as documented in the SEP. They shall

include participation by subject matter experts who are independent of the program (i.e., peer review), unless specifically waived by the SEP approval authority as documented in the SEP.

CM tracks the design approved at the CDR and documents any approved changes in the AD Configuration. The prime contractor then provides the AB configuration records, a list that should be reflected in the completed manufacturing documents, and FCA/PCA serves to confirm the AD against the AB configuration. CM is crucial for providing both the incoming and outgoing documentation for each, ultimately resulting in the Technical Baseline (TBL) documentation. In some cases, CM, as a branch of the SEIT organization, may be responsible for completing the FCA/PCA.

In order to complete the audit process, the CM manages all proposed baseline changes from their submittal/documentation to approval/disapproval, and ultimately, their implementation or dismissal. Using such practices as version control, search and correlation schemes, concurrency, provenance, isolation, redundancy, and mapping, the baseline products can be planned, communicated, controlled, directed, organized and consensus driven. These products include:

1. Stakeholder requirements (including the system boundaries, the scope of activities, the objectives, and the relevance)
2. Set of technologies, their means, and implications
3. System functions, processes, performances, behaviors, results, and losses
4. Risks associated with each requirement
    a. Individual
    b. Cumulative
5. Style, manner, and methodologies used to identify and correct problems, and make decisions
6. Engineering and multi-disciplinary practices that are acceptable
7. Compilation of information according to various conditions

a. Current
b. Anticipated
c. Range

8. Baseline schedule, cost, and forecast, and
9. Policy, regulations, rules, guidance documents.

CM best practices should be used. These include implementation of a CCB process, authoring and complying with a CM plan, but is ultimately to be applied IAW the relevant guidance and regulations of the governing organization(s). For GPS satellite design and manufacture, that would be the GPSW and the affiliated contract company(ies). Once the baseline is established and documented, the relevant program can take possession of and control that baseline IAW the contractual specifications and agreements in place.

G. PERSONNEL

The audit is ultimately the responsibility of the Configuration Management and SEIT team(s). So being, personnel are provided primarily by those teams. However, this team should be augmented as appropriate by DCMA, test team personnel, PM personnel, and any other outside support required. DCMA is responsible for the independent review and support of certain defense contracts. Because GPS programs typically meet the criteria for DCMA oversight, it is valuable to leverage the relationship to take advantage of their expertise, prevent duplication of effort, prevent unnecessary expenses and for the added value of an independent review.

While the FCA/PCA can be used to validate the manufacturing and assembly process, it should also validate the technician and engineering support used for production. This can be done as part of the AB/AD configuration review but ultimately serves to approve the process and manning necessary for SV production by providing data on the associated processes and their timelines.

H. RISK MANAGEMENT

Although Risk Management (RM) is an independent program activity, it is also a primary objective of the Technical Review process and, therefore, the FCA/PCA. This is to say the FCA/PCA should help provide for risk identification and risk mitigation as it serves to assess the technical, physical, and strategic shortcomings of a design and production process while providing a forum for such concerns to be acted on and addressed in a timely manner.

Risks to and risks identified in the FCA/PCA should be captured and managed appropriately IAW the local RM processes. Risks to the of the FCA/PCA event itself can be initiated and managed as a program risk and can be worked by the responsible party, the SEIT team, or a working group. Risks to hardware or production identified in the FCA/PCA event itself should be documented in the minutes and action item-tracking log as necessary. The team can then work to accomplish the mitigating activities as described for action items. However, existing RM processes and tools should be used to manage the actual risk as it affects the program.

I. CHAPTER SUMMARY

Each program may have different variations or implementations of the tools mentioned here; however, this thesis is intended to provide a guideline for the application of those tools and processes in order to accomplish the associated objectives of the Technical Review process in an efficient manner. Scheduling is fundamental to any program and its significant events and milestones. Being one of those milestones, FCA/PCA is no different and should be actively monitored and managed in the program schedule. Funding management, configuration management, personnel management, risk management, and action item tracking are critical components of program management as well and help to accomplish the workload. One of the critical processes is the test program and requirements verification effort. Like any other significant program activity, all of the tools available can be used to aid in the

completion of the test program for the purpose of verifying the functionality and performance of the product in regard to the respective requirements. Meanwhile, Certification Sheets are not commonly used in other applications but are prescribed for the FCA/PCA in the Mil-Std guidelines. These certification sheets along with all the other management tools should be well used to complete a successful FCA/PCA and establish a technical baseline.

IV. APPLICATION OF STUDY: EXECUTION OF A GPS SPACE SEGMENT FCA/PCA AND BEYOND

A. INTRODUCTION

FCA/PCA is a critical event for most DoD production programs, however each program is unique in its application of the audit process to varying degrees. Therefore, each program should plan for its completion sufficiently in advance. Once the FCA/PCA has been completed there are several implementations that allow for speedier completion of the remainder of the satellites. The necessary parts and material should be purchased and readily available in the appropriate queue; the production process for these satellites will have been refined, optimized and approved; and as long as each of the following satellites are built to the FCA/PCA approved product baseline, they do not have to undergo any more testing than a subset of the qualification tests known as acceptance tests and finally be approved by the program Engineering Review Board (ERB) for the verification of workmanship proficiency. These efficiencies pertain primarily to GPS, which requires at least 24 satellites to populate the Medium Earth Orbit constellation at about 22,000 km above the earth, but is relevant for any number of multiple satellite programs.

B. STRATEGY

In order to complete an FCA/PCA, a program must map out an appropriate execution strategy that includes Entry and Exit (E/E) criteria, a timeline that coincides with respective program accomplishments, logistical planning, personnel provisions, coordination with invested parties and a determination on whether there will be one culminating event/audit, two separate audits or multiple incremental audits. Such a strategy requires an agreement between all parties involved, namely the contractor and the customer. Coordination with DCMA is necessary and is a criteria for accomplishment. If it is not previously stipulated in the contract, these parties must also agree on the

implementation of the audit process (i.e., whether the FCA/PCA will be accomplished in increments or as a single event, how the team member roles and responsibilities will be determined, what the guiding policies and procedures will be, and what the E/E criteria will be). Each of these components of the audit process helps determine the execution strategy. Usually the implementation strategy is determined based on the size and complexity of a program, the depth of the team(s) experience and personnel availability, and the timeline available for accomplishment. For example, delivering three satellites with 3,529 functions within five years results in 445 configuration items that need to be tracked and managed. A formal, written audit plan and procedure is mandatory to prevent unexpected cost impacts and schedule delays.

GPS space system acquisition is typically on a large enough scale, in terms of cost and complexity, that an incremental approach to the completion of the FCA/PCA is warranted. In fact, the incremental approach is recommended for most programs. This approach allows the program to schedule their reviews over a period in order to spread the effort out into manageable tasks and review sections or segments of the program. These incremental reviews should be accomplished, ideally on a frequent basis, once the established criteria are met for the completion of different components, subsystems, tests, or as other significant accomplishments related to the PBL are achieved. Audits of this nature also provide for real-time or near real-time review of data while allowing for updates with any significant change as necessary, reducing the risk and duration of program delays in the case of anomalies or discrepancies. At the very least, reviewing the data in the integration and test process flow is convenient, efficient and even essential, for the V&V of the requirements and qualification program: consisting of test, analysis, and demonstration. To accomplish the FCA/PCA during the execution of the test program, the objective of each specific test phase must be well understood and stated. The requirements to be verified

should be documented in order to determine whether sufficient data is provided from the testing. With this planning in place the FCA/PCA can be an efficient and effective tool to transition from the design and development.

C. RESULTS

Having completed the Test program and V&V process through the FCA/PCA, the program can approve the acceptance program for the remaining articles to be produced outside of the qualification program. Having qualified the manufacturing procedures, tooling, personnel and resources the FCA/PCA should provide for a streamlined production process. It also serves to validate the design for the entire fleet to allow the ATP to be applied to the remainder of the fleet to simply verify workmanship, as opposed to workmanship and design performance that were verified in the qualification vehicle.

D. BASELINE CHANGES AND CONFIGURATION CONTROL

As satellites are produced, there may be some necessary modifications or changes that need to be applied to the baseline due to unforeseen source changes, facility changes, design or process improvements, or changes in constraints (e.g., schedule, cost, policy, or skill set). It is the program's responsibility to determine which entity(ies) is(are) responsible for the design and configuration control prior to FCA/PCA. Because of their knowledge, experience, and investment in the documentation and the deliverable product, it is reasonable and essential to identify the designer or owner of the relevant specification level for that responsibility. It is then necessary to identify who is responsible for configuration control as well as how much and what kind of customer oversight is required post FCA/PCA. If the contractor is responsible for the design and production of the satellite(s), the responsibility of configuration control could well reside with them until the design is validated through FCA/PCA. The contract may specify the transfer of ownership at that time; however, the customer may decide to leave the CM function with the contractor.

E. CHAPTER SUMMARY

Configuration items developed at the government's expense require an FCA/PCA prior to acceptance of the item. These guidelines and principles will serve to improve efficiency and provide a structure for the execution thereof in the GPSW as well as any other adoptive agency at SMC and beyond. To provide formal documentation of this process, a sufficiently well defined and documented plan is necessary. With an adequate plan in place, the process will carry the program through the V&V phase to establish a baseline for the acceptance testing or full rate production phase. Through that transition, the continued configuration management function/responsibility remains a crucial role to be coordinated by the customer with the contractor as appropriate.

V. CONCLUSIONS

A. KEY POINTS AND RECOMMENDATIONS

It is in the best interest of all stakeholders to determine early what is expected in and from the FCA/PCA for a program. Such planning provides key insight into what needs to be accomplished when in order to make the necessary preparations. Planning for such things as a proto-qualification program that combines qualification testing, requirements verification and data to support the completion of the FCA, is a complicated enterprise. It is also difficult to plan resources, activities, tasks and schedules that are dependent on other independent activities and processes. To assist in the process, the following is a list of recommended items that should be specified and documented early:

1. FCA/PCA E/E Criteria
2. Configuration control plan for pre and post FCA/PCA
3. Acceptance versus Qualification verification requirements
4. Program specific tailoring of MIL-STD 1521B Certification Sheets

The final step, or purpose, of an FCA/PCA is to provide for the review, inspection, certification and documentation for the customer's purchase of the design and, in the case that the proto-qualification process is used, the first production article. This entails the use of a Department of Defense Form 250 (DD-250) to document the transfer of ownership for the subject property to the government. For GPS, and other satellite programs, this receipt for the hardware will be provided at the shipping dock, or at the time of shipment, as an Initial DD-250 IAW the relevant contract. The space vehicle can then be transferred by the government itself or a hand receipt, Department of Defense Form 1149 (DD-1149), can be written to allow temporary control by another entity for the purpose of shipment. Finally, IAW the contract language, the respective portion of the satellite system can be purchased with the Final DD-250 once the system has been launched, checked out and handed over to the government for control in flight.

B. RESEARCH CONCLUSIONS

To answer the questions initiating this research:

1. What are the necessary outputs of a technical review FCA/PCA?
    a. Product baseline to be used as the contract baseline for production
    b. Validation of the contractor's production process
    c. Assessment of risk to proceed into production of the remaining units
    d. Physical inspection of the qualification or proto-qualification unit to ensure that the product is built IAW the work instructions and procedures identified
    e. Validation of the As Built Configuration Record (ABCR) to the As Designed (AD) baseline
    f. Conclusion of the qualification or proto-qualification test phase and approval for the "kick-off" of the Acceptance Test Phase (ATP) for Validation and Verification (V&V) of the workmanship of the products and the allocated and functional aspects of the development baseline
2. What means should be used for the culmination of a technical review for a GPS Space Segment Acquisition Block?
    a. Coordination between appropriate parties (i.e., DCMA, prime contractor, program personnel, etc.) for the completion of the necessary audits, inspections, etc.
    b. Ensure closure of established entry and exit criteria
    c. Documentation and signatures in the certification sheets found in MIL-STD-973 and tailored in Appendix A
    d. Agreed to and documented configuration control of the production articles
3. What objectives and methods are appropriate for the government FCA/PCA process in order to establish the technical baseline for GPS and/or SMC space acquisition programs?
    a. Test program validation
    b. Proto-qualification or qualification of the technical baseline and space vehicle hardware, design and functionality
    c. Incremental audits/reviews and physical inspections

4. Which strategies are most beneficial for system engineering in the production of GPS Space Vehicles?

   Due to the size, value and complexity, among other factors, the following aspects are the most beneficial and even critical methods for establishing the technical baseline for GPS and similar satellite acquisition programs.

   a. Proto-qualification

   b. An incremental review and physical inspection

5. How can these objectives and methods be applied effectively for the acquisition of a GPS space segment?

   Through the following disciplines/tools:

   a. Schedule Management

   b. Funding management

   c. Configuration management

   d. Personnel management

   e. Risk management

   f. Action item tracking

   g. Certification Sheets

6. What role does configuration management play in the maintenance of a technical baseline for production purposes?

   CM plays a critical role in establishing and maintaining the technical baseline for a program. Pg 78 of DoDI 5000.2 dated 08 Dec 08 states:

   The PM shall use a configuration management approach to establish and control product attributes and the technical baseline across the total system life cycle. This approach shall identify, document, audit, and control the functional and physical characteristics of the system design; track any changes; provide an audit trail of Technical reviews of program progress shall be event-driven and conducted when the system under development meets the review entrance criteria as documented in the SEP.

C. AREAS FOR FURTHER RESEARCH

A valuable area for expansion of this thesis would be to include the other milestones within the overall Technical Review process. This would include lower level direction for the completion of specific events such as SRR, SDR, PDR, and CDR.

With GPS as an example of space vehicle design, development and production, the methods and principals described here can be tailored, expanded, and directly applied to the acquisition of similar systems. After making a determination regarding the extent of applicability to any unique program, these guidelines could at least serve as a foundation to establish further guidelines and policies.

D. SUMMARY

The FCA/PCA and related milestones are a critical piece of DoD production & acquisition programs. General guidance seems to be readily available; however, it is crucial that each unique program establish the standards of application to provide for a smooth and complete process. The suggestions presented here serve as an example, or potentially as a foundation for, what is needed at the center, system, and program levels to efficiently and effectively establish a proper technical baseline for a space systems acquisition program.

Without these procedures and documentation, a program is less likely to succeed, if not actually unable to maintain its initial schedule, meet its prescribed system requirements, or remain within budget. It is recommended that the Space and Missiles System Center consider the potential benefits outlined here for adopting some principles of baselining procedural issues, and revised documentation standards in order to provide for the standardization of replicated processes at the detailed levels of SV production. An efficacious technical baseline can be established more efficiently to provide for a repeatable production process that will produce a system that meets the specified requirements in a more timely manner at a more predictable cost.

APPENDIX A. TAILORED FUNCTIONAL CONFIGURATION AUDIT (FCA) AND PHYSICAL CONFIGURATION AUDIT (PCA) CHECKLISTS AND CERTIFICATION SHEETS ORIGINATING FROM MIL-STD 973

FCA Checklist

Contract: _____ **Date:** _____
Contractor: _____
Nomenclature: _____
CI Identifier: _____

CONTRACTOR REQUIREMENTS	**YES**	**NO**
1. Verification Test Procedures Submitted	_____	_____
2. Waiver/Deviation List Prepared	_____	_____
3. Verification Testing Completed	_____	_____
4. Verification Test Results Compiled & Available	_____	_____
5. FCA Facilities Available	_____	_____
6. Verification Test Procedures Reviewed and Approved	_____	_____
7. Verification Testing Witnessed	_____	_____
8. Verification Test Data and Results Reviewed Approved	_____	_____

COMMENTS:
_____
_____
_____
_____
_____

Final FCA CERTIFICATION SHEET NO. 1
TEST PROCEDURES AND RESULTS

Contract: _____ **Date:** _____
Contractor: _____
Nomenclature: _____
CI Identifier: _____

Verification Test Procedures and Results. The verification test/analysis results have been reviewed to ensure that testing is adequate, properly done and certified. (All test procedures and interface documents shall be reviewed to assure that the documents have been approved by the Government. All test data sheets shall be reviewed to assure that the test was witnessed by a representative of the Government). *Caveat: The Government does not always have approval authority on the Test Procedures. In which case, the Mil-STD-973 FCA Cert Sheet #1 can be tailored to: The verification test/analysis results have been reviewed to ensure that testing is adequate, properly done and certified. All test procedures and interface documents have been reviewed to assure that planned testing and test flow has been reviewed by the Government to ensure they meet with Government Approval.*

Open Actions:
NONE

~~Attached is a list of the documents reviewed.~~

Documents reviewed:

Check One

☐ Procedures and results reviewed satisfy the requirements and are accepted.
See Attachment ___ for comments.

☐ Attached is a list of deficiencies.

Signature(s) of FCA/PCA Team Member(s)

Company/Function – Name	Signature	DATE
(Contractor) SV SE Lead Name		
(Contractor) Quality Assurance Lead Name		
(Contractor) Configuration/Data Mgt Name		
USAF, GPSW, Block # Lead Name		

~~FCA LIST OF DOCUMENTS REVIEWED~~

~~CONFIGURATION ITEM NOMENCLATURE:~~ _____

~~DOCUMENT CONTROL NUMBER~~	~~DESCRIPTION~~	~~REMARKS~~

FCA CERTIFICATION SHEET NO. 2
DEVIATIONS/WAIVERS

Contract: _____ **Date:** _____
Contractor: _____
Nomenclature: _____
CI Identifier: _____

Review of Deviations/Waivers. A review of all deviations/waivers to military specifications and standards that have been approved. The purpose is to determine the extent to which the equipment ~~(s)~~/computer software undergoing FCA vary from ~~one application vary from one~~ applicable specifications and standards and to form a basis for satisfactory compliance with these specifications and standards. In accordance with this paragraph, all applicable deviations/waivers have been reviewed with the following results:

Open Actions:

Documents Reviewed:
Request for Deviations and Waivers (RDW) Master Log
RDW System Assessment
Nonconformity Processing

Check One

☐ The equipment~~(s)~~/computer software listed on Certification Sheet No. 1 of this report complies with contract requirements. ~~See attachment ___ for comments~~.

☐ Attached is a ~~summary of FCA discrepancies~~ list of deficiencies.

Signature(s) of FCA Team Member(s)

Company/Function – Name	Signature	DATE
(Contractor) SV SE Lead Name		
(Contractor) Quality Assurance Lead Name		
(Contractor) Configuration/Data Mgt Name		
USAF, GPSW, Block # Lead Name		

A. Deviation/Waiver Review Team Instructions. All approved waivers and deviations to contract requirements shall be reviewed and recorded. Also, record any part of the FCA that fails to meet specifications or standards but is not an approved waiver/ deviation.

B. Results of Team Review. List the deviations/waivers against the equipment/ computer software being FCA'd that were reviewed.

~~FCA WAIVERS/DEVIATIONS~~

~~CONFIGURATION ITEM NOMENCLATURE:~~ _____

~~DOCUMENT NUMBER, TITLE~~	~~REFERENCE (Spec, STD, Etc.)~~	~~CCB OR MRB APPROVAL/ DIRECTIVE~~	~~REQUIREMENT WAIVED~~	~~REMARKS~~

Space Vehicle Deviations and Waivers

*Note – the same list of deviations and waivers are listed on FCA Cert Sheet #2 and PCA Cert Sheet #6

ID	Classification	RDW Title	Status
DSP####	Minor		Released

PCA CHECKLIST

Contract: _____ **Date:** _____
Contractor: _____
Nomenclature: _____
CI Identifier: _____

The following hardware, computer software, documentation shall be available for audit:

	YES	NO
1. Approved final draft of the Configuration Item Product specification		____
2. A list delineating both approved and outstanding changes against the CI		____
3. Complete shortage list		____
4. Acceptance test procedures and associated test results		____
5. Engineering drawings with outstanding changes		____
6. Operating, maintenance and illustrated parts breakdown manuals		____
7. List of approved material review actions		____
8. List of approved and/or pending waivers/deviations		____
9. Approved nomenclature and nameplate		____
10. Manuscript copy of all software CI manuals		____
11. Computer software version description documents		____
12. Current set of listings and updated design descriptions or other means of design portrayal for each software CI		____
13. FCA minutes for each CI		____
14. Program parts selection list (PPSL)		____
15. Final configuration verification report “as-designed/as-built”		____
16. Completed hardware representing various stages of manufacture		____

COMMENTS: _____
_____
_____

PCA CERTIFICATION SHEET 1
For Equipment / Computer Software

Contract: _____ **Date:** _____
Contractor: _____
Nomenclature: _____
CI Identifier: _____

Product Baseline. The following documents of the issue and date shown comprise the product baseline for the listed equipment~~(s)~~ /-computer software.

Open Action Items:
NONE

Documents Reviewed:
SS09-0048 Rev - Space Vehicle Technical Baseline Guide and Listing
SS09-0085 Rev - Space Vehicle 1 As-Built Configuration Record Gate 13
(See PIMS record A009876 for working copy)

The following plan is to be accomplished post SV ship to validate the launch configuration of the vehicle.

1. Vehicle is configured for launch at the Eastern Launch Site (ELS)
2. Boeing Launch IPT Lead will provide as-built data to reflect the final launch configuration
3. Boeing CM Lead will update the ABCR reflecting the launch configuration
4. Government CM Lead will review the ABCR and document findings as appropriate

~~ASSEMBLY TOP SPEC NO. DRAWING NO. ISSUE EQUIPMENT / COMPUTER SOFTWARE NOMENCLATURE~~

~~Attached is a list of the documents reviewed~~

Signature(s) of PCA Team Member(s)

Company/Function – Name	Signature	DATE
(Contractor) SV SE Lead Name		
(Contractor) Quality Assurance Lead		
(Contractor) Configuration/Data Mgt		
USAF, GPSW, Block # Lead Name		

PCA CERTIFICATION SHEET 2
(For Equipment/ Computer Software)

Contract: _____ **Date:** _____
Contractor: _____
Nomenclature: _____
CI Identifier: _____

Specification Review and Validation. SV Specification has been reviewed and validated to assure that they adequately define the configuration item and the necessary testing, mobility/transportability and packaging requirements. *Note: All requirement verification documents used to verify launch vehicles only include verification information for Delta. The program may use an alternate Launch Vehicle, Atlas, at a later Space Vehicle. Additional requirement verification documents will be addressed as appropriate when specific launch vehicles are selected.

Open Actions:

Documents reviewed:

Specification Review and Validation Instructions:
The detailed specifications listed in table 1 shall be reviewed for compliance with the applicable requirements. Each specification shall serve as the basic document for configuration control of the subject configuration items. The information contained within the specifications shall be audited at the PCA.

1. Specifications Reviewed and Validated

Control Number	Description	Revision

2. Test Requirements Documents* (TRDs) Reviewed

TRD	Sequence	Title	Revision

***Note: Test Requirements Documents are not part of the Space Vehicle Technical Baseline Listing.**

Check One

☐ The Product Specifications are complete and adequately define the configuration item. They shall, therefore, constitute the product baseline.

☐ The Product Specifications are unacceptable. ~~See attachment ____ for a list of discrepancies~~.

Signature(s) of PCA Team Member(s)

Company/Function – Name	Signature	DATE
(Contractor) SV SE Lead Name		
(Contractor) Quality Assurance Lead		
(Contractor) Configuration/Data Mgt		
USAF, GPSW, Block # Lead Name		

~~A. Specification Review and Validation Instructions. The detailed specifications listed in paragraph B. below shall be reviewed for compliance with the applicable requirements. Each specification shall serve as the basic document for configuration control of the subject configuration items. The information contained within the specifications shall be audited at the PCA.~~

~~B. Review and Validation Results.~~

~~1. Specifications reviewed and validated:~~

~~SPEC NO. PART NO. DATE EQUIPMENT/COMPUTER SOFTWARE NOMENCLATURE~~

~~(see attached)~~

2. Specifications Reviewed and Disapproved:
(Provide attachment for causes.)

PCA LIST OF SPECIFICATIONS REVIEWED

CONFIGURATION ITEM NOMENCLATURE:
_____

SPECIFICATION NUMBER	PART NUMBER	DATE / REV. NO.	EQUIPMENT/COMPUTER SOFTWARE NOMENCLATURE

PCA CERTIFICATION SHEET 3
Equipment

Contract: _____ **Date:** _____
Contractor: _____
Nomenclature: _____
CI Identifier: _____

Drawing Review. Drawings have been compared with the equipment to ensure that the latest drawing change letter has been incorporated into the equipment, that part numbers agree with the drawings, and that the drawings are complete and accurately describe the equipment.

Open Actions:
None

Documents Reviewed:
SS02-0015 Parts, Materials and Processes Selection List (ADP 153)
Government Physical Configuration Verification Report
All items listed in Table below
Check One
☒ The drawings are complete and accurately describe the equipment.
☐ HWCI/engineering drawing package; parts approved and listed on PMPSL
☐ Attached is a list of deficiencies

Drawing Review Results
The following drawings were reviewed by the Customer PCA sub-team:

Part Number	Nomenclature	Revision	CEO

~~Attached is a list of the documents reviewed~~

Check One

~~☐ The drawings are complete and accurately describe the equipment.~~

~~☐ The drawings are compatible with the applicable contract Program Parts Selection List (PPSL).~~

☐ HWCI/engineering drawing package; parts approved and listed on PPSL.

☐ Attachment _____ is a list of discrepancies. Reference action items.

Signature (s) of PCA Team Member (s)

Company/Function – Name	Signature	DATE
(Contractor) SV SE Lead Name		
(Contractor) Quality Assurance Lead		
(Contractor) Configuration/Data Mgt		
USAF, GPSW, Block # Lead Name		

A. Drawing Review Results. The following drawings were reviewed by the PCA drawing review sub-teams:

(see next page)

PCA LIST OF DRAWINGS REVIEWED

CONFIGURATION ITEM NOMENCLATURE:

DRAWING NUMBER AND REVISION	NOMENCLATURE	REMARKS

PCA CERTIFICATION SHEET 4
(Equipment)

Contract: _____ **Date:** _____
Contractor: _____
Nomenclature: _____
CI Identifier: _____

Acceptance Test Procedures and Results. The acceptance test procedures have been reviewed for adequacy and the acceptance test results have been reviewed to ensure that the testing has been properly done and certified.

~~Attachment _ is a list of the documents reviewed.~~
Check One
☐ ~~Procedures and results reviewed satisfy the requirements and are accepted.~~

☐ ~~Attachment ___ is a list of discrepancies. Reference action items.~~

Open Actions:
NONE
Documents Reviewed:
DOP and GOP revision and review date can be found in SS09-0047.

Procedure #	Document Nomenclature

Check One
☒ The Acceptance Test Procedures have been reviewed and they satisfy the requirements and are accepted.
☐ Attached is a list of discrepancies.

Acceptance Test Procedures: The following acceptance test procedures were reviewed and deemed adequate.

Document Number	Description	Revision	Date

Signature(s) of FCA/PCA Team Member(s)

Company/Function – Name	Signature	DATE
(Contractor) SV SE Lead Name		
(Contractor) Quality Assurance Lead		
(Contractor) Configuration/Data Mgt		
USAF, GPSW, Block # Lead Name		

~~A. Acceptance Test Procedures. The following acceptance test procedures were reviewed by the ATP Sub-Team:~~

~~DOCUMENT NUMBER DATE/REV LTR DOCUMENT TITLE STATUS~~

~~B. Acceptance Test Results. The following acceptance test results documentation were reviewed by the ATP Sub-Team:~~

~~DOCUMENT NUMBER DATE/REV LTR DOCUMENT TITLE STATUS~~

PCA CERTIFICATION SHEET 5
(For Equipment/Computer Software)

Contract: _____ **Date:** _____
Contractor: _____
Nomenclature: _____
CI Identifier: _____

Review of Shortages and Unincorporated Design Changes. The shortages and Unincorporated design changes listed on the proposed ~~DD Form 250 "Material Inspection and Receiving Report" have been reviewed.~~ Wide Area Work Flow (WAWF, electronic DD Form 250, "Material Inspection and Receiving Report"), and other records have been reviewed.

Shortages and Unincorporated Design Changes are described here and are captured in the Wide Area Work Flow (WAWF, electronic DD 250). Each are categorized as follows:

1. SV Ship – Shipment of Space Vehicle to Launch Site
2. SV Launch – Activities at launch site up to consent to launch
3. Sustainment – Activities on-orbit
4. None – Document updates or hardware Fly-As-Is dispositions

Open Actions:
See Attachment A

Documents Reviewed:
Gate 13 Lien Summary

Attachments:
Shortages and Unincorporated Design Changes
Gate Closure Summary

Check One

☐ ~~There are no shortages or Unincorporated design changes.~~

☐ ~~Attachment _____ is a list of shortages and/or Unincorporated design changes, and the recommended corrective action required. Reference action items.~~

Check all that apply:

☐ A list of shortages are captured in Attachment A

☐ A list of Unincorporated Design Changes and the recommended corrective action is captured in Attachment A

☐ There are no shortages, unincorporated design changes, Unaccomplished tasks/open issues, or specified discrepancies

~~Signature (s) of PCA Team Member (s)~~

Signature(s) of FCA/PCA Team Member(s)

Company/Function –	Signature	DATE
(Contractor) SV SE Lead Name		
(Contractor) Quality Assurance Lead		
(Contractor) Configuration/Data Mgt		
USAF, GPSW, Block ## Lead Name		

A. Review of Shortages and Unincorporated Design Changes. All shortages and Unincorporated design changes listed on the proposed Wide Area Work Flow (WAWF, electronic DD Form 250 "Material Inspection and Receiving Report"), shall be reviewed by the Government or their designated representatives for a determination of what changes should be accomplished in the field and what changes should be accomplished at the contractor's facility. The ~~review team~~ Government shall also determine if the reported shortages and Unincorporated changes are complete.

B. Results. Attachment A ~~L~~lists the shortages and Unincorporated design changes that were reviewed in compliance with requirements, including the agreed-to corrective action.

PCA Certification Sheet #5
Attachment A

Definitions from MIL-HDBK-61A

- Shortage
  - Known deficiencies (e.g., requirement partially implemented) on the system
- Unincorporated Design Change
  - A change to the current approved configuration documentation of a configuration item that was not incorporated
  - Any alteration to a product or its released configuration documentation that was not incorporated.

Unique Identifier	Item	Tracking Mechanism	Type	Description	Comments	Effectivity	Risk	Constraint
						All	Low	None

PCA CERTIFICATION SHEET 6
(For Equipment/Computer Software)

Contract: _____ **Date:** _____
Contractor: _____
Nomenclature: _____
CI Identifier: _____

Review of Deviation/Waivers: A review of all deviations/waivers to military specifications, standards and contract requirements that have been approved. The purpose is to determine the extent to which the equipment ~~(s)~~/computer software undergoing PCA vary from ~~one application vary from one~~ applicable specifications and standards and to form a basis for satisfactory compliance with these specifications and standards. In accordance with this paragraph, all applicable deviations/waivers have been reviewed with the following results:

Open Actions:
WBP0299 Receive Customer Approval

Documents Reviewed:

PIMS Record A011679	RDW Master Log
PIMS Record A014953	RDW System Assessment
SIS-PRO-6655	Nonconformity Processing

Check One

☐ The equipment(s)/computer software listed on Certification Sheet No. 1 of this report complies with all applicable specifications and standards.

☐ ~~Attachment ___~~ Attached is a list of discrepancies and/or comments.

Signature(s) of FCA/PCA Team Member(s)

Company/Function – Name	Signature	DATE
(Contractor) SV SE Lead Name		
(Contractor) Quality Assurance Lead		
(Contractor) Configuration/Data Mgt		
USAF, GPSW, Block ## Lead Name		

Deviation/Waiver Review Team Instructions. All approved waivers and deviations to contract requirements shall be reviewed and recorded. Also, record any part of the PCA which fails to meet specifications or standards but is not an approved waiver/deviation.

Results of Team Review. List the deviations/waivers against the equipment/computer software being PCA'd that were reviewed.

PCA WAIVERS/DEVIATIONS

CONFIGURATION ITEM NOMENCLATURE:

_____

DOCUMENT CONTROL NUMBER	REFERENCE (Spec, STD, Etc.)	CCB OR MRB APPROVAL/ DIRECTIVE	REQUIREMENT WAIVED	REMARKS

PCA CERTIFICATION SHEET 7
(For Equipment/Computer Software)

Contract: _____ **Date:** _____
Contractor: _____
Nomenclature: _____
CI Identifier: _____

~~Examination of the Proposed DD Form 250. The DD Form 250 has been examined to ensure that it adequately defines the equipment/computer software and that unaccomplished tasks are identified as deficiencies.~~

Review of Contractor's Engineering Release and Change Control System.
The contractor's engineering release system and change control procedures have been reviewed to ensure that they are adequate to properly control the processing and formal release of engineering changes.

Open Actions:

Documents Reviewed:

Check One

☒ The contractor's engineering release system and change control procedures are
adequate for the processing and formal release of engineering changes.

☐ Attached is a list of deficiencies.

Signature(s) of FCA/PCA Team Member(s)

Company/Function – Name	Signature	DATE
(Contractor) SV SE Lead Name		
(Contractor) Quality Assurance Lead		
(Contractor) Configuration/Data Mgt		
USAF, GPSW, Block ## Lead Name		

PCA CERTIFICATION SHEET 8
(Equipment)

Contract: _____ **Date:** _____
Contractor: _____
Nomenclature: _____
CI Identifier: _____

Review of Logistics Support Plan for Pre-operational Support. The Logistics Support Plan for Pre-operational Support has been reviewed to ensure that it is adequate to support the acquisition phase and is compatible with the operational phase maintenance concept and support requirements.

Check One

☐ The contractor's Logistic Plan for pre-operational support will fulfill the acquisition phase requirements and is compatible with operational phase needs.

☐ ~~Attachment _____ is a list of deficiencies~~. Reference action items.

2. Review of Long Lead Time Items and Provisioned Items Processed Prior to PCA. Long Lead-Time items released, and items provisioned, prior to PCA have been reviewed to ensure that obsolete items resulting from pre-PCA design changes are purged from the system. Where basic items may be upgraded by rework or modification these actions have been verified as accomplished or in process based upon design change notice.

Check One

☐ Long lead time items and provisioned items processed, prior to PCA, are all of current configuration at time of PCA or are in work.

☐ Attachment _____ is a list of deficiencies. Reference action items.

Signature(s) of FCA/PCA Team Member(s)

Company/Function – Name	Signature	DATE
(Contractor) SV SE Lead Name		
(Contractor) Quality Assurance Lead		
(Contractor) Configuration/Data Mgt		
USAF, GPSW, Block ## Lead Name		

PHYSICAL CONFIGURATION AUDIT
Certification Sheet #9

Contract: _____ **Date:** _____
Contractor: _____
Nomenclature: _____
CI Identifier: _____

1. Review of Integrated Support Plan (ISP) for Pre-operational Support. The Integrated Support Plan (ISP) for Pre-operational Support has been reviewed to ensure that it is adequate to support the acquisition phase and is compatible with the operational phase maintenance concept and support requirements.

Check One

☒ The contractor's ISP for pre-operational support will fulfill the acquisition phase requirements and is compatible with operational phase needs.

☐ Attached is a list of deficiencies.

2. Production Process, Long Lead Items and Obsolete/Spare Parts are properly Addressed and Accounted for. Long lead time items released, and items provisioned, prior to PCA have been reviewed to ensure that obsolete items resulting from pre-PCA design changes are purged from the system. Where basic items may be upgraded by rework or modification these actions have been verified as accomplished or in process based upon design change notice.

1. Long lead time items and provisioned items processed, prior to PCA, are all of current configuration at time of PCA or are in work. Any items removed from the design have been removed from the engineering Bill of Material and purged from the system if necessary.

2. All engineering for rework/modification of SV1 items is verified as released in the system or are in process based upon design notice and work is complete.

3. Production line parts acquisition and sparing strategy for SV1 has been reviewed to ensure production readiness, including proper handling / accounting of critical items in accordance with applicable requirements.

☒ Long lead time items and provisioned items processed, prior to PCA, are all of current configuration at time of PCA or are in work.

☒ Critical Items Handling Plan reviewed and found to be adequate with the following exceptions: ASD and CES loss of paperwork from storage facility in Seal Beach; high bay loss power, so loss environmental control.

Open Actions:
None

Documents Reviewed:

Document Number	Revision	Title

Signature(s) of FCA/PCA Team Member(s)

Company/Function – Name	Signature	DATE
(Contractor) SV SE Lead Name		
(Contractor) Quality Assurance Lead Name		
(Contractor) Configuration/Data Mgt Name		
USAF, GPSW, Block ## Lead Name		

APPENDIX B. GLOSSARY

Acceptance Test Phase (ATP): Portion of a program after the design has been qualified by the qualification testing and FCA/PCA. Acceptance Testing verifies that each end item meets the performance specifications/requirements.

Acceptance Vehicles: Space vehicles produced during the Acceptance Test Phase.

Allocated Baseline (ABL): The initially approved documentation describing an item's functional, interoperability, and interface characteristics that are allocated from those of a system or a higher-level configuration item; interface requirements with interfacing configuration items; additional design constraints, and the verification required to demonstrate the achievement of those specified characteristics.

Allocated Configuration Documentation (ACD): The approved allocated baseline (ABL) and approved changes.

As Built Configuration Record (ABCR): All documentation necessary to detail the final product configuration typically provided for each vehicle. The record includes such things as the Bill of Materials (BOM) line item/level, part number, nomenclature, reference designator, quantity, and serial number of each part along with the as-designed/as-built information

As Designed (AD) Configuration Record: The configuration baseline documentation that specifies how each end item should be built (i.e., without any waivers or deviations that may exist for an individual unit or group of units).

Assembly, Integration, & Test (AI&T): The entity responsible for, location for or function of manufacturing, producing, and testing production units.

Baseline: Agreed-upon budget, manning, technical, and milestone requirements between the cognizant parties or appropriate authority.

Build Approval/Production Decision: Decision made by the Milestone Decision Authority (MDA) to allow a program to commence with production.

Capability Development Document (CDD): A document that captures the information necessary to develop a proposed program(s), normally using an evolutionary acquisition (EA) strategy. The CDD outlines an affordable increment of militarily useful, logistically supportable, and technically mature capability. The CDD may define multiple increments if there is sufficient definition of the

performance attributes key performance parameters (KPPs), key system attributes (KSAs), and other attributes) to allow approval of multiple increments. The CDD supports a Milestone B decision review (Hagan, 2009).

Capability Production Document (CPD): A document that addresses the production elements specific to a single increment of an acquisition program. The CPD defines an increment of militarily useful, logistically supportable, and technically mature capability that is ready for a production decision. The CPD must be validated and approved prior to a Milestone C decision review (Hagan, 2009).

Configuration Baseline (CBL): Configuration documentation formally designated by the Government at a specific time during a Configuration Item's (CI's) life cycle. Configuration baselines, plus approved changes from those baselines, constitute the current approved configuration documentation. There are three formally designated configuration baselines in the life cycle of a CI, namely the functional, allocated, and product baselines.

Configuration Control Board (CCB): Panel responsible for defining and managing the technical baseline of an end item.

Configuration Management (CM): The technical and administrative direction and surveillance actions taken to identify and document the functional and physical characteristics of a configuration item (CI), to control changes to a CI and its characteristics, and to record and report change processing and implementation status. It provides a complete audit trail of decisions and design modifications.

Consent to Break Configuration (CTB): The decision provided by the designated authority to change the test**.**

Contract Baseline: Documentation, specifications, drawings, requirements that define what is to be completed by the prime contractor in terms of integrated and tested end item hardware.

Critical Design Review (CDR): A multidisciplinary technical review, conducted for each configuration item when detailed design is essentially complete, with the objective of ensuring that the detailed design of the configuration item or system under review can proceed into fabrication, system integration, demonstration, and test, and can meet the stated performance and engineering specialty requirements of the configuration item (CI) development specifications within cost (program budget), schedule (program schedule), risk, and other system constraints.

Defense Contract Management Agency (DCMA): Department of Defense (DoD) component that works directly with Defense suppliers to help ensure that DoD, Federal, and allied government supplies and services are delivered as

close to contractual requirements as possible. DCMA typically provides contract and technical experts to provide for quality assurance oversight of a DoD program.

Deviation: A specific written authorization granted prior to the manufacture of an item, to depart from a particular requirement or procedure for a specific number of units or a specified period of time.

End of Life (EOL): The projected timeframe in which a system/unit is expected or the point in time when a system/unit actually starts performing below minimum requirement(s) due to design, component or hardware degradation from the operational environment, conditions, or use.

Engineering Change Proposal (ECP): MIL-STD-973 document requesting a form, fit or function change to the design. The system or segment specification establishes the functional baseline.

Engineering Review Board (ERB): The sub-panel, typically chaired by the lead/chief engineer, that pre-reviews/approves items for technical adequacy as designated/delegated by the program authority.

Functional Baseline (FBL): The approved documentation describing a system's or item's functional, interoperability, and interface characteristics and the verification required to demonstrate the achievement of those specified characteristics.

Functional Configuration Documentation (FCD): The approved functional baseline (FBL) plus approved changes.

Global Positioning System (GPS): System of satellites, ground control and user components that operate to provide precision navigation and timing signals primarily for navigation data.

Initial Operational Capability (IOC): In general, attained when some units and/or organizations in the force structure scheduled to receive a system have received it and have the ability to employ and maintain it. The specifics for any particular system IOC are defined in that system's Capability Development Document (CDD) and Capability Production Document (CPD) (Hagan, 2009).

Key Performance Parameters (KPPs): Those attributes or characteristics of a system that are considered critical or essential to the development of an effective military capability and that make a significant contribution to the characteristics of the future joint force. A KPP normally has a threshold representing the minimum acceptable value achievable at low-to-moderate risk, and an objective, representing the desired operational goal but at higher risk in cost, schedule, and performance. KPPs are contained in the Capability Development Document (CDD) and the Capability Production Document (CPD) and are included verbatim

in the Acquisition Program Baseline (APB). Certain KPPs may be mandatory or selectively applied, depending on the system. See Acquisition Program Baseline (APB), Validation Authority, Capability Development Document (CDD), Capability Production Document (CPD), Mandatory Key Performance Parameters (KPPs), Selectively Applied Key Performance Parameters (KPPs), Threshold Value, Objective Value, and Joint Potential Designator (JPD) (Hagan, 2009).

Mission Assurance Review (MAR): An engineering assessment completed by a group independent of the design, production and operation of a system to critique potential weaknesses in any aspect that would unacceptably limit, degrade or jeopardize performance, primarily with respect to End of Life requirements.

Post-Deployment Review (PDR): Conducted by DoD components beginning at Initial Operational Capability (IOC) and then nominally every 3 to 5 years or when precipitated by changes in requirements/design or performance problems. These periodic assessments verify whether the fielded system continues to meet or exceed thresholds and objectives for cost, performance, and support parameters approved at the full-rate production (FRP) decision. In addition to comparing actual versus expected levels of performance and support, at minimum the reviews should include Product Support Integrator/Product Support Provider's performance, including effectiveness of sustained materiel readiness implementation, product improvements incorporated, and configuration control (Defense Acquisition University, 2010).

Post Test Review (PTR): Assessment completed by the test engineering team and others, as designated, to determine the adequacy of the testing and review the data for trending and data analysis as required by the program system engineering authorities.

Preliminary Design Review (PDR): A review conducted on each configuration item to evaluate the progress, technical adequacy, and risk resolution of the selected design approach; to determine its compatibility with performance and engineering requirements of the development specification; and to establish the existence and compatibility of the physical and functional interfaces among the item and other items of equipment, facilities, computer programs, and personnel. Normally conducted during the early part of the System Development and Demonstration (SDD) Phase.

Product Baseline (PBL): The approved documentation describing all of the necessary functional and physical characteristics of the configuration item and the selected functional and physical characteristics designated for production acceptance testing and tests necessary for support of the configuration item.

Product Configuration Documentation (PCD): The approved product baseline (PBL) plus approved changes.

Proto-Flight Qualification (Proto Qual) Program: The process of qualifying a design by testing a fully operational end item to a specified level that will adequately determine the performance characteristics, considering end of life conditions, but will leave enough performance margin to allow the unit to be used in an operational capacity, unlike a full qualification program in which a fully operational end item is tested to maximum performance levels, even to failure in some cases, to determine its operational bounds.

Qualification Program or Qualification Testing: The determination of whether a unit built to a specified design is capable of meeting the system requirements through the end of its life, with a predetermined safety factor, in the relevant operational environments.

Run for Record (RFR): The testing and data documented as the officially completed test required for verification of performance and/or production in accordance with the test compliance matrix and the qualification or acceptance testing plan.

Space Vehicle (SV): The end item production product for a space program, typically in the form of a satellite.

System Baseline: technical performance, schedule, and cost baselines.

System Verification Review (SVR): The SVR is a multidisciplinary technical review conducted to ensure that the system under review can proceed into low-rate initial production (LRIP) and/or full-rate production (FRP) within cost (program budget), schedule (program schedule), risk, and other system constraints.

Technical Baseline (TBL): Configuration documentation that identifies and defines the item's functional characteristics (i.e., specifications, interface documents, and architectural views).

Technical Performance Measure (TPM): Describes all the activities undertaken by the Government to obtain design status beyond that treating schedule and cost. A TPM manager is defined as the product design assessment, which estimates through tests, the values of essential performance parameters of the current design of work breakdown structure (WBS) product elements. It forecasts the values to be achieved through the planned technical program effort, measures differences between achieved values and those allocated to the product element by the system engineering process, and determines the impact of these differences on system effectiveness.

Test Compliance Matrix (TCM): The designation of specific tests to be used to verify each requirement or group of requirements.

Verification and Validation (V&V): Validation is the process of confirming that the higher-level specifications or requirements are fully provided for and traceable to the product requirements. Verification is the task of ensuring that the product indeed satisfies those requirements in the end item.

Waiver: A written authorization to accept an item for use “as is” after it has been found to depart from specified requirements.

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